TRANSLATION ACES INC.
29 Broadway ◆ Suite 2301
New York, NY 10006-3279
Tel. (212) 269-4660 ◆ Fax (212) 269-4662

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(73) Patentholder:

Schade KG, 5970 Plattenberg, DE

(72) Inventor(s):

Strunk, Harald, 5970 Plattenberg, DE

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(54) **Method for Producing Hollow Injection Molded Articles of Plastic and Device for Carrying Out the Method**

A plastic molded part having thin and thick walled sections is to be produced by forming of a melt injected into the mold cavity 5 of a mold through use of a pressurized gas such that especially the transitions from the thick walled regions to the thin walled regions 16, 17 can be formed cleanly and to the correct shape with no flow marks.

The volume of the interior spaces for thick regions of the mold cavity 5 of the mold 1 corresponding to the thick walled regions 14, 16 can be altered by means of an auxiliary tool 4 that functions as a displacement body. Prior to final forming of the melt into the molded part, the mold's interior spaces for thick regions are significantly smaller than after conclusion of the forming process.

The method in accordance with the invention and the device for carrying out said method can be used, for example, for trim parts, armrests, and similar parts in automotive manufacture, but also for furniture parts such as tabletops, backrests, and the like, as well as for all other conceivable areas of application that use plastic injection molded parts having a wide variety of cross-section designs with thick walled and thin walled regions.

Method for Producing Hollow Injection Molded Articles of Plastic and Device for Carrying Out the Method

Description

The invention concerns a method for producing hollow injection molded articles of plastic having thick and thin walled regions in cross-section wherein a predetermined amount of a polymer melt is injected into the essentially closed and suitably contoured mold cavity of an injection mold and is formed into the molded article by means of a pressurized gas, and the invention also concerns a device for carrying out the inventive method.

A prior art method is known from EP-A 02 89 230, for example. In this method, the polymer melt is injected into the interior of the mold that is shaped appropriately for the outer contour of the molded part. In this process, the melt preferentially collects in the regions in which the material is opposed by the least resistance, which is to say in regions in which the height of the mold chamber cross-section is the greatest, before it enters those regions of cross-section where thinner wall thickness are formed. In many of the molded articles to be injection-molded, for example center consoles, trim parts, armrests, and similar parts used in automotive manufacture, but also in furniture parts such as tabletops, armrests, backrests, and the like, or in any other parts in all conceivable areas of application, the ratio of cross-sections of adjacent thick walled regions to thin walled regions is often too large to produce smooth, well-formed transitions in cross-section. In practice, the transitions between adjacent regions of

smaller and larger cross-sectional thickness in such injection-molded parts always represent critical regions, because it is often unavoidable during forming of the melt in the manufacturing process that the molded articles break easily at the transition points, especially when the ratio of the thick walled region to the thin walled region is too large.

Also, visible flow marks and sink marks often form at such places because the gas that is injected into the melt and forces the melt outward against the interior walls of the mold cavity is opposed by an excessively high resistance in the transition regions and the gas cannot distribute uniformly throughout the entire cavity, additionally resulting in uneven forming of the melt. If the transitions between the thick and thin walled regions are too narrow, in actual practice the melt may not penetrate into the thin walled regions of the mold at all, or may be distributed so unevenly that high reject rates occur with molded parts produced by the known method.

Consequently, the object of the invention is to further develop a method of the generic type such that the injection molded articles can be produced with correct contours and free of flaws even when the ratio between cross-sections of adjacent thick and thin walled regions is especially large, so that production reject rates can be reduced to a minimum.

The invention has the further object of creating a device that operates according to the inventive method that is simple in design and operates reliably.

The object with regard to the method is attained in accordance with the invention in that, in order to form the melt into the molded article, the cross-section of the mold cavity is changed essentially in the regions which form the thick parts of the molded article. This achieves the result that the melt injected into the mold cavity no longer

collects primarily in the mold's interior spaces for thick walled regions, but rather the melt is specifically forced into the mold's interior spaces for thin walled regions as well during forming depending on the ratio by which the mold cross-section is changed.

As a result of the variability in the cavity cross-section, a preforming effectively takes place even before the final forming of the molded article. Since the suggestion in accordance with the invention significantly reduces deformation work as compared to the prior art methods, shorter injection molding cycles and thus significantly improved injection performance are achieved.

It is useful for the starting volume in the thick walled regions of the mold cavity to be smallest at the beginning of melt injection, with the mold cavity expanded to its greatest volume no later than upon conclusion of gas injection. As a result, the penetration of the melt into the thin walled regions of the mold is enhanced because the mold is only gradually expanded to a larger interior volume, and thus the ratio between the thick and thin walled regions in the vicinity of the transitions is likewise gradually altered.

It is useful for the starting volume of the mold cavity to be kept large enough initially that the entire melt quantity is first injected into the cavity before the mold cavity is enlarged and the melt is formed. The type and contour of the molded article to be injection molded determine the chosen ratio between the starting and final volumes of the mold cavity.

In accordance with another embodiment of the invention, the change in the volume of the mold cavity, especially in the region of the interior spaces for thick walled

regions, is changed either in a single step, in a series of steps, or continuously, as suitable for forming of the melt.

Although changing the volume in a single step seems to be the simplest technical solution, melt flow during forming can be controlled better, and thus a higher quality molded article is achieved, with discontinuous enlargement in small steps or continuous enlargement.

The point in time when the gas is injected into the cavity to form the melt is specified by means of two alternative examples in claims 5 and 6. It is left to the practitioner to decide which option to use in practice.

The object with respect to the device is achieved in accordance with the invention by at least one movable auxiliary tool that changes the volume of the mold's interior spaces for thick walled regions. Such a movable auxiliary tool is very simple to implement in practice, wherein in accordance with one suggestion of the invention the auxiliary tool can have one or more projections such as plungers, rings, or the like, that travel into the mold's interior spaces for thick walled regions. The interior volume of the mold can be varied as desired, depending on how far the auxiliary tool extends into the interior spaces for thick walled regions.

Advantageous embodiments of the device are described in claims 8 through 12.

An example embodiment of the invention is explained below. The drawings show:

Fig. 1 the device in vertical section, in which the auxiliary tool is in its top starting position,

Fig. 2 a cross-section as in Fig. 1, in which the auxiliary tool is in its bottom final position, and

Fig. 3 a molded part produced with the device from Figs. 1 and 2 viewed in a plane along the section line III-III in Fig. 1.

The device shown in Figs. 1 and 2 comprises a mold designated as a whole with 1, which essentially consists of a top part 2, a bottom part 3, and an auxiliary tool 4 that can travel into and out of the mold cavity 5 delimited by the walls of the top part 2 and bottom part 3, which in Figs. 1 and 2 is already filled with an injection molding compound. A comparison of Figs. 1 and 2 makes it clear that the volume of the mold cavity 5 can be changed as a function of the applicable operating position of the auxiliary tool 4 with respect to the mold 1, wherein the representation in Fig. 1 shows the smallest mold cavity volume and that in Fig. 2 shows the enlarged final volume of the mold chamber.

Figs. 2 and 3 show that the finished injection molded piece 6 is composed of a thin-walled plate with hollow ribs 8 surrounding its edge region and ribs 9 running diagonally inward from the edge regions. The thick walled hollow ribs 8, 9 of the molded article, each of which is tubular in cross-section, are joined to one another and terminate in the center at 10' in a connecting piece 10 in the bottom view of the molded article (Fig. 3). The specific contour of the mold chamber interior 5 is a result of the desired outside contour of the molded article 6 to be produced.

*The auxiliary tool 4 consists in the example shown of a base plate 11 arranged outside and beneath the mold bottom part 3 on which are formed ribs 12, 13 that face

toward the top part 2 and correspond to the desired contour of the thick walled hollow ribs 8, 9 of the molded article 6. The ribs 12, 13 are long enough that in the top position of the auxiliary tool 4 (Fig. 1) they extend far into the interior 5 of the mold, passing through suitably adapted bearing guides in the bottom part 3 of the mold 1. The rib contours 12, 13 form the interior spaces for thick walled regions labeled 14, 16. The remaining interior cross-sections encompass the thin walled region 15. The top position of the auxiliary tool 4 determines the starting volume and the bottom position determines the final volume of the interior spaces for thick walled regions of the mold 1. The thick and thin walled regions of the molded article 6 that correspond to one another, and their transitions that merge into one another, can be seen particularly clearly in Fig. 3. The top part 2 and the bottom part 3 of the mold 1 can be separated from one another to remove the molded part 6 after completion of each injection cycle by known means that are not shown. When the bottom tool is moved apart from the top tool, the auxiliary tool 4 follows the movement of the bottom part 3, but to change the mold cavity volume 5 is driven independently by a piston-cylinder unit 18 that forms the motion drive.

The melt is injected into the mold chamber 5 cyclically through a channel 19 in the top part 2 of the mold 1 in a known manner. In the example shown, the channel 19 is located in the center of the mold 1, but can also be placed in any other suitable position desired. The gas is injected into the mold chamber through a hole 20 in the top part. In a variation on the embodiment shown, multiple feed inlets may of course be provided for the gas and/or melt instead of one feed inlet each. It is also possible to introduce the gas and the melt through a shared line into the mold cavity. The melt and

gas feed inlet may enter from the top as well as the bottom, depending on the system type.

The manufacturing process proceeds in that first the auxiliary tool 4 is moved by the piston-cylinder unit 17, 18 to the top position as in Fig. 1 prior to injection of the melt during an injection cycle. At this time, the outer contours of the rib ends 12, 13 protruding into the mold cavity are located a distance from the interior surfaces of the mold cavity 5. The distance corresponds approximately to the thickness of the walls of the plate of the molded article 6 to be produced. The recesses for thick regions in the mold 1 in the bottom part 3 or top part 2 are always large enough that the top contour regions of the ends of the ribs 12, 13 extending into the cavity lie inside the mold while forming gaps from the interior surfaces of the recesses for thick regions, or in other words, the top edge regions of the rib ends 12, 13 are surrounded by the melt.

Fig. 1 shows that the molded article is initially preformed as a solid part as a result of the auxiliary tool extended into the mold cavity, so that during this preforming stage of the manufacturing process there are no critical transitions between the thin walled regions and the regions that will later be thick walled. During this preforming stage, wall thicknesses of the molded article are achieved that are largely uniform since the melt can distribute itself unhindered in the gaps of essentially equal thickness in both the thin walled and thick walled regions in the hollow chamber, thus avoiding the circumstance of the melt dispersing first in the cavities for thick regions because of the low resistance with the associated risk that it then will not be able to disperse suitably evenly in the thin walled regions. Once the gas is forced into the mold chamber, regardless of whether this takes place during or after the melt feed, the auxiliary tool 4 is

moved to its final bottom position (Fig. 2) either continuously, in a series of steps, or even suddenly in one step in that the piston-cylinder unit 17, 18 is appropriately subjected to pressure and controlled. As the auxiliary tool moves out, the rib ends 12, 13 gradually open the initially small gap cross-section in the thick-walled region (Fig. 1) up to its largest final volume (Fig. 2), and the gas, which likewise always seeks the path of least resistance for its dispersal, disperses through the areas of larger cross-section that form the thick-walled regions and forces the melt material from the center outward against the interior walls of the mold cavity, thereby forming hollows that are uniform throughout the entire molded article and communicate through the channels and intermediate connections 8, 9, 10', 10 (Fig. 3) inside the molded article so that gentle transitions and evenly formed cross-sectional contours are developed throughout the entire molded article. After the melt has cured, the mold is opened by moving the bottom part 3 apart from the top part 2 of the mold, the gas pressure is released to the atmosphere or in another way, and the finished molded article is removed or ejected from the opened mold.

Any desired variations are possible within the framework of the example embodiment shown. Thus, the auxiliary tool 4 shown can additionally be moved on guide pillars or pins. Also, it is not absolutely necessary to always choose the smallest mold cavity cross-section as the starting position for the auxiliary tool in the initial stage, but instead, it is of course possible for the starting volume to first assume some intermediate stage, which is to say to be kept large enough initially that the entire melt quantity can be first injected into the mold cavity cross-section before the mold cavity is gradually enlarged and the melt is formed. Although it is always stated with regard to

the described example that the cross-section of the mold cavity can be changed in the regions where the thick walled sections of the molded article are to be produced, it is of course also possible to undertake the volume change during the production process in the thin walled sections, or even in both the thin and thick walled sections. In the final analysis, this is a function of the percentage ratio between the injected compound and the free final volume of the molded article or of the actual cross-sectional shape of the desired molded article design.

Claims

1. Method for producing hollow injection molded articles of plastic having thick and thin walled regions in cross-section wherein a predetermined amount of a polymer melt is injected into the essentially closed and suitably contoured mold cavity of an injection mold and is formed into the molded article by means of a pressurized gas, **characterized in that**, in order to form the melt into the molded article, the cross-section of the mold cavity is changed essentially in the regions which form the thick parts of the molded article.

2. Method from claim 1, **characterized in that** the starting volume in the thick walled regions of the mold cavity is smallest at the beginning of melt injection, and the mold cavity is expanded to its greatest volume no later than upon conclusion of gas injection.

3. Method from claim 1, **characterized in that** the starting volume of the mold cavity is initially kept large enough that the entire melt quantity is first injected into the mold cavity before the mold cavity is enlarged and the melt is formed.

4. Method from claims 1 – 3, **characterized in that** the final volume of the mold cavity is accomplished by enlargement in the region of the thick parts in a single step, in a series of steps, or continuously, as suitable for forming of the melt.

5. Method from one or more of the preceding claims, **characterized in that** first the melt is injected into the mold cavity and the gas is injected thereafter.

6. Method from one or more of the preceding claims, **characterized in that** the melt and the gas are introduced into the mold cavity simultaneously.

7. Device for carrying out a method for producing hollow injection molded articles of plastic having thick and thin walled regions in cross-section wherein a predetermined amount of a polymer melt is injected into the essentially closed and suitably contoured mold cavity of an injection mold and is formed into the molded article by means of a pressurized gas, **characterized by** a movable auxiliary tool that changes the volume of at least the mold's interior spaces for thick walled regions.

8. Device from claim 7, **characterized in that** the auxiliary tool has one or more projections that travel into the mold's interior spaces for thick walled regions, such as plungers, rings, or the like, for example.

9. Device from claim 7 or 8, **characterized in that** the auxiliary tool can be moved relative to the mold cavity on guide pillars or pins.

10. Device from one of claims 7 – 9, **characterized in that** the auxiliary tool is driven by a piston-cylinder unit.

11. Device from one or more of claims 7 – 10, **characterized in that** the gas and the melt may be injected or introduced into the interior of the mold through a shared line.

12. Device from one or more of claims 7 – 10, **characterized in that** the gas and the melt may be injected or introduced into the interior of the mold through one or more separate lines apiece.

Herewith 3 sheet(s) of drawings
